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BUREAU OF PLANT INDUSTRY.

AGRICULTURE ON THE YUMA RECLAMATION PROJECT.[1]

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THE SOIL AND TOPOGRAPHY.

The agricultural area of the Yuma Reclamation Project includes about 130,000 acres lying on both sides of the Colorado River in Arizona and California immediately north of the boundary between the United States and Mexico. Of this about 90,000 acres are valley land, formerly subject to overflow by the river, and 40,000 acres are on a bench or mesa directly south of Yuma. This mesa land is about 100 feet above the river and is irrigable by pumping. The valley soil is composed of silt deposited by the river during the annual floods, and much of it is of very recent deposition. The character of the soil with respect to fineness is extremely variable, depending upon the velocity of the water where it was laid down. The irrigable area lies in a narrow strip along the river between low bluffs of gravel which mark the edge of the mesa. Since 1906 the valley lands have been protected from overflows by levees on either side of the river. Prior to that time agricultural operations on the valley land had been precarious, because of the annual floods.

The subsoil underlying the valley is easily pervious to water, and, since it all lies close to the river channel, the ground water is not far below the surface. The height of the underground water fluctuates with the height of the water in the river.

In topography the valley lands are nearly level, with a gentle slope to the south of about 1 foot to the mile. However, there are numerous old sloughs and stream channels left by the river as well as hummocks and sand hills formed from drifting soil. These must be leveled before the land can be irrigated to advantage. This leveling is often expensive, sometimes costing as much as $80 to $100 per acre, though the average cost is probably not over $30 per acre. In its natural condition the valley land was covered with a heavy growth of timber and underbrush. The timber consisted chiefly of cottonwood, willow, and mesquite. The underbrush was arrow weed and a large saltbush. The clearing of the land of timber and underbrush has been expensive, costing from $5 to $25 per acre.

[1] Issued May 3, 1913.

The mesa soil is a mixture of fine sand and gravel. It takes water readily at first, but after a few years of irrigation with the muddy Colorado River water it becomes less pervious and tends to pack and bake on drying. There appears to be much less variation in the mesa soil than in that of the valley. Except for a few hummocks, the mesa is smooth, with a gentle slope to the south and west. It lies at the east of the valley and is separated from it by a steep slope. The native vegetation on the mesa is very sparse, being limited to a few desert shrubs and some inconspicuous annual plants. The cost of preparing mesa land for irrigation will be comparatively slight.

About 10 per cent of the valley land on the Yuma Project contains a sufficiently high percentage of alkali salts to render the growing of ordinary farm crops precarious. These salts are composed chiefly of chlorids and sulphates, with very little black alkali. It has been found necessary to provide a drainage system to keep down the water table to a depth from which the capillary action of the soil will not carry the water to the surface. Such a system is now under construction.

THE CLIMATE.

The climate is warm throughout the year, the temperature for a period of 35 years ranging from a minimum of 16° to a maximum of 120° F. Field operations can be carried on throughout the year, and, if it is desired to do so, the land may be used by growing crops practically all the time. The rainfall is light, averaging about 3 inches a year, and is not a factor in crop production.

There is marked difference between the temperature conditions on the mesa and in the valley during the winter nights, when frosts occur. The mesa is almost free from frost, even in the coldest weather, while freezing temperatures are of frequent occurrence in the valley during the winter months. Such comparative records as are available show that the mean minimum winter temperature is about 9 degrees lower in the valley than on the mesa.

AGRICULTURAL DEVELOPMENT.

The valley was first occupied by American farmers in 1890. The early agriculture was confined to the production of grain and alfalfa. For many years the water supply was precarious and the danger from overflow was such as to retard the permanent improvement of the land. Since the construction of the protecting levees by the Reclamation Service and with the installation of irrigation works, which insure an adequate supply of water, there has been more diversification of crops, and much permanent improvement has taken place.

Notwithstanding many efforts to establish other agricultural industries, the production of alfalfa has remained by far the most important industry of the region. Alfalfa fields that are properly handled yield annually six or seven cuttings of hay that average 1 to 1½ tons per cutting per acre. Except during a few brief periods the price of alfalfa hay has been high. The local demand for hay required for the stock used in the construction of the irrigation works has been relatively large up to the present time, but as the construction work is nearing completion the local demand for hay is likely to become less active.

In addition to the production of alfalfa hay, there has also been an increasingly large production of alfalfa seed. This crop has proved both reliable and profitable. The average yield from 2,824 acres in 1912 was 288 pounds per acre, with a few fields yielding as high as 900 pounds per acre. During the season an alfalfa field produces not only a crop of seed, but four cuttings of hay as well, one cutting being made before the seed crop and the others thereafter. The alfalfa seed has been clean and of good quality, and it has been marketed to advantage through a local farmers' association.

INDUSTRIES IN THE EXPERIMENTAL STAGE.

Several crops have been grown experimentally on the project on a scale large enough to merit consideration. These crops include cantaloupes, watermelons, onions, and sweet potatoes. Of the several causes that have contributed to the failure of these crops industrially the two most important ones are high transportation charges and inexperience in marketing. This applies particularly to cantaloupes and watermelons. In the case of onions the high-priced early market has been occupied by onions from southern Texas, where the crop is two or three weeks earlier than in Yuma Valley, and it has been found possible to ship carload lots of Texas onions through Yuma to Pacific coast markets before the Yuma crop was ready to harvest.

Many other crops have been tried on the project, including grain crops, cotton, small fruits, and vegetables. Wheat, barley, and rye are planted in the fall and are harvested early the following summer in time to permit the production of a crop of corn, milo, or kafir on the same land. Barley is also extensively planted for hay. Alfalfa fields that have been run out by Bermuda grass are frequently broken up in the fall and planted to barley or wheat. Beans have been produced on a field basis, but with few exceptions have not proved a very remunerative crop. The citrus fruits, including oranges, grapefruit, and lemons, have been grown successfully on the high mesa, while pears, peaches, apricots, plums, figs, dates, almonds, and strawberries have been grown on a sufficiently large scale to prove the adaptability of the valley lands to their culture. Practically all the common vegetables have been grown with success when put in at the right season and properly cared for. For instance, potatoes, cabbage, lettuce, radishes, and carrots are planted during the autumn months, while such vegetables as tomatoes, eggplant, cucumbers, and melons are planted after danger from spring frosts is over.

THE KIND OF CROPS NEEDED.

Present conditions indicate that the Yuma Project must develop along the line of producing crop products which are sufficiently high priced to bear the cost of long shipment to consuming markets. It is not probable that the local consumption of crop products will ever be a factor of large importance. The natural conditions of climate, soil, and water supply are such as to favor a very large production per acre. The important thing now is to determine which of the many possible crops promise to give the largest returns and to select those which provide for the most suitable utilization of the farm labor and at the same time provide for suitable crop rotation.

It is not to be expected that unless a large development of live-stock industries takes place there will long continue a satisfactory market for alfalfa hay. The alfalfa seed crop, however, should remain a profitable one unless some serious disease or insect pest appears. But alfalfa production, whether for hay or seed, is more profitable when the land is occasionally cleaned up by the production of some cultivated crop. This is particularly true where, as at Yuma, the alfalfa fields are quickly invaded by Bermuda grass and high production of hay can be expected only during the first few years. While it is true that a fair seed crop may be obtained from alfalfa fields which are badly infested with Bermuda grass, it is inadvisable to allow such fields to remain, because of the increased cost of subjugating the Bermuda soil and fitting the land again for other crops.

CROPS SUITABLE TO THE REGION.

Of crops suitable for rotation with alfalfa there might be mentioned Indian corn, milo, beans, wheat, barley, and cotton. While such crops as corn, milo, beans, wheat, and barley are all relatively low priced, the climate is such that the small grains can be grown during the winter months and followed by corn, milo, or beans, giving two crops from the same land in one year. Cotton, on the other hand, occupies the land during practically the entire season, but if the proper variety is used the net returns should be larger than for the grain crops mentioned. Cotton is particularly well adapted to rotation with alfalfa because of the high production possible on alfalfa sod.

Cotton is especially useful in subjugating land infested with Bermuda grass and Johnson grass. It requires comparatively little irrigation but much cultivation during the early summer, and later the plants shade the ground so effectively that Bermuda grass may be completely eradicated by a single crop of cotton. Cotton possesses the additional advantage of relatively high value in proportion to transportation cost, besides finding a ready cash market at all times. It is not quickly perishable and may thus be held without risk in case market conditions at harvest are not favorable.

While alfalfa in rotation with cotton may serve as the basis of a profitable agriculture, particularly if accompanied by one or more of the possible animal industries, it is to be expected that several of the more intensive plant industries, such as orchard fruits, will be developed.

From present indications it seems probable that certain varieties of pears, such as Bartletts (both early and late), Winter Nelis, and Seckel will do well.

The date palm thrives well on the Yuma Project, and as soon as an adequate supply of offshoots of good varieties is available this crop should become a very profitable one. Meanwhile it is possible to purchase seeds in large quantity, and a good proportion of the seedling date palms are likely to yield fruit suitable for home consumption and home market. Moreover, the chance of obtaining valuable new varieties among the seedlings is not to be overlooked.

Another orchard fruit of much promise in the Yuma Valley is the fig. There are two important classes of figs, both of which grow well at Yuma—the Smyrna and the common fig. The latter class includes such varieties as the Brown Turkey, White Adriatic, and Black Mission, which yield fruit without cross-pollination. With proper orchard handling two crops of fruit may be produced every year. The fresh fruits of these varieties find a ready and increasingly large sale, and they may also be dried or preserved before selling.

The Smyrna fig differs from the common fig in requiring cross-pollination. The fresh fruits are marketed to some extent, but the Smyrna-fig industry is based on the dried fruit. While it remains to be demonstrated whether or not the Yuma Valley is adapted to the production of Smyrna figs, it seems worth a thorough trial. Figs are well suited to the orchardist operating on a small scale, because the packing operations, whether for the fresh or dried fruit, are relatively simple and inexpensive. The product is also high priced, and consequently the transportation charge is proportionately small.

CONCLUSIONS.

The fullest agricultural prosperity of the Yuma Reclamation Project requires the utilization of crops which can be combined in suitable rotation systems and which yield products that can be shipped long distances to market.

Alfalfa and live stock are likely to be the principal features of this agriculture, at least at first.

The orchard fruit crops, such as dates, figs, and pears, may gradually become important.

Alfalfa seed production has been profitable, and it is probable that with more experience in producing and marketing it may be made still more so.

Egyptian cotton promises to find a prominent place among the annual crops and is particularly suitable for rotation with alfalfa.

A number of other crops are worthy ot trial.

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EFFECTS OF CROSS-POLLINATION ON THE SIZE OF SEED IN MAIZE.[1]

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INTRODUCTION.

There is a popular belief that the immediate effect of planting two varieties of maize in close proximity is to increase the yield of both varieties. Failure to appreciate some of the peculiar characteristics of the maize plant accounts for the delay in bringing this question to the test. With other crops the changes which follow crossing become apparent only when the hybrid embryos develop into plants in the next generation after the crossing takes place. In maize, however, foreign pollen often has an immediate effect in altering the color and texture of the seeds, a phenomenon that has received a special name, xenia. It seemed, therefore, not unreasonable to believe that the size of the seed as well as the color or texture might be affected by crossing.

In connection with a study of hybrids between United States varieties and a new type of maize from China it was observed that one of the effects of crossing the two types was an increase in the size of the seed in the same year the crossing was done.[2] Similar results in crosses of this Chinese variety have been recorded by Roberts.[3]

Additional data on this subject were obtained in connection with an experiment planned to test the possibility of selective pollination in maize. Pollen taken from two plants belonging to different varieties was mixed and applied to the stigmas or silks of one of the varieties, thus producing pure and hybrid seed on the same ear. The phenomenon of xenia made it possible to so select the varieties with respect to color of the seed that it was possible to distinguish between the hybrid seeds and those resulting from the pollen of the same variety.

[1] Issued May 3, 1913.

[2] Collins, G. N. A new type of Indian corn from China. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 161, p. 18, 1909.

[3] Roberts, H. F. First generation hybrids of American × Chinese corn. American Breeders' Association, Annual Report, v. 7/8, p. 374, 1912.

The hybrid and pure seeds from each of the ears, when weighed separately, exhibited such striking differences that it is thought advisable to place the results on record. In every instance the hybrid seed was larger than the pure seed borne on the same ear, the increase ranging from 3 to 21 per cent.

LIST OF VARIETIES CROSSED.

The experiments involved the following varieties:

Missouri Cob Pipe, or Collier.—The well-known, large-cobbed variety used in the manufacture of corn-cob pipes. The seeds are white. In our specimens the average weight per 1,000 seeds is 310 grams.

Gracillima.—A variety of pop corn isolated from a variegated variety, the seed of which was originally secured from Germany. The seeds are white. The average weight per 1,000 seeds is 67 grams.

Variegated.—Similar to the preceding. Isolated from a podded variety. The white seeds of this strain average 141 grams per 1,000 seeds.

Hickory King.—A large, thin-seeded, white dent variety. The seeds of the strain used in these experiments averaged 480 grams per 1,000.

Mexico Black.—A Mexican variety with slightly dented "shoe-peg" seeds and an intensely black aleurone. The original seed of this variety consisted of one ear secured from the Valley of Mexico, Seed and Plant Introduction No. 27074. The seeds of this ear averaged 295 grams per 1,000. As grown in our experiments the seeds are smaller, averaging only 231 grams per 1,000.

Algeria.—A variety of pop corn with beaked seeds and purple aleurone. The average weight of the seeds is 125 grams per 1,000.

DESCRIPTION OF THE EXPERIMENTS.

It will be seen that the varieties involved comprise four with white seeds and two with colored seeds. The color in these seeds is located in the aleurone cells, the outer layer of the endosperm. Previous experiments have established the fact that when pollen from one of these black-seeded varieties is used to pollinate an ear of the white varieties the resulting seed is colored.

In the experiments to be described, the silks of the white-seeded varieties were dusted with a mixture of pollen from the same white variety and pollen of a different variety with colored seeds. The ears that result from an operation of this kind have white kernels that represent pure seed of the variety and colored seeds that are hybrids between the white and colored varieties. In some instances the pollen of the white variety contributed to the mixture was taken from the same plant that was being pollinated, in which case the resulting white seeds were not only pure for the variety, but were self-pollinated. The two kinds of seeds were, of course, mixed indiscriminately on the ear and developed under identical conditions. Where consistent differences in the size of the two kinds of seed occur it is therefore safe to assume that they are due to differences induced by the use of the various kinds of pollen. The number of seeds from a single ear are usually large enough to afford reliable averages and justify confidence in even relatively small differences.

Eleven such ears were secured, and the results with respect to the weight of the hybrid and pure seed are given in Table I. Individual plant numbers are given, since in many instances a plant which bears one of the pollinated ears also figures as the source of pollen in another cross. Where more than one ear of a plant was pollinated the second and third ears from the top of the plant are given the individual plant number followed by a figure 2 or 3. To avoid large decimals, the average weight is given in terms of 1,000 seeds instead of in terms of a single seed.

It will be seen that in every instance the size of the seed was materially increased by the foreign pollen. The increase ranges from 2.8 to 21.1 per cent. It should also be noted that the rate of increase bears no direct relation to the size of seed in the variety used as the source of pollen. The seeds of the Algeria variety average only half as heavy as those of Mexico Black, yet the increases secured when Algeria is used as the source of pollen are rather greater than when Mexico Black pollen is used.

TABLE I.—*Increase in size of seed secured by cross-pollination.*

Ear-bearing plant.		Source of the mixed pollen.				Number of seeds.		Weight per 1,000 seeds.		Increase with cross-pollination.
		White.		Colored.						
Variety.	No.	Variety.	Plant No.	Variety.	Plant No.	Pure.	Hybrid.	Pure.	Hybrid.	
								Grams.	*Grams.*	*Per cent.*
Pipe	259	Self		Mexican Black.	643	511	220	294	337	14.6 ± 0.7
	259-2	Pipe	267	...do	643	541	248	268	293	9.3 ± 1.0
	267	Self		...do	643	553	20	371	420	13.2 ± .6
Gracillima	1212	...do		Algeria	1301	171	235	65	79	21.1 ± .9
	1220	...do		Mexican Black.	669	99	211	74	80	7.9 ± .8
	1220-2	Gracillima	1212	...do	669	350	94	66	74	12.3 ± 1.4
	1220-3	...do	1212	Algeria	1301	139	175	65	74	13.8 ± 2.1
Variegated	1227	Self		Mexican Black.	653	402	81	137	156	13.9 ± 2.2
	1227-2	Variegated	1228	...do	653	111	245	140	148	5.7 ± .6
	1228	...do	1227	...do	653	496	25	144	148	2.8 ± .9
Hickory King	219	Self		...do	643	140	104	522	557	6.7 ± .2

VOLUME AND SPECIFIC GRAVITY OF SEEDS.

The differences in weight observed in these seeds might come about through differences in size or through differences in composition, or a combination of both. To determine this point, volumetric and specific-gravity determinations were made of the pure and hybrid seed of all the ears. The results showed that the observed differences in weight were associated with corresponding differences in volume. No differences in the specific gravity of pure and hybrid seed from the same ear could be detected.

SIZE AND COLOR NOT CORRELATED.

In order to distinguish between pure-bred and hybrid seed on the same ear only those hybrids with colored aleurone could be utilized. It might be urged that there was a tendency for colored seeds to be heavier than white and that we have been measuring differences between colored and white seed rather than differences between pure and hybrid seed. Fortunately, there was material at hand to test this point. In 1911 a cross had been made between Variegated and Mexico Black, two of the varieties used in these experiments. This hybrid was grown and a number of self-pollinated ears secured in 1912. These ears all had both white and colored seeds. A comparison of the weight of the white and colored seed from each of these ears showed only the ordinary fluctuating differences between the two classes.

SELECTIVE POLLINATION AND CROWDING OF SEED.

Before accepting the increased size of the hybrid kernels on mixed ears as an indication of the increased yields that may be secured from cross-pollination, it will be necessary to consider the possibility that the hybrid kernels might develop at the expense of the neighboring pure kernels. In that case the average size of the seed would not be increased if all the seeds of the ear were cross-pollinated.

If the pure kernels are weak or develop more slowly, the hybrid kernels may gain by being less crowded, or the hybrid kernels may grow more rapidly at first because of more prompt pollination and may then rob their pure-seed neighbors by direct appropriation of a larger share of the available food materials.

A fortunate accident in pollination throws light on both of these questions. An ear of "Maryland White Dent" was pollinated by a plant of the same variety. Seven days later, in making a second application of pollen, a plant belonging to a red variety with yellow endosperm was accidentally used as the source of pollen, the mistake being noted at the time.

In the resulting ear the two kinds of seed were easily distinguished. The pure seeds resulting from the first pollination were pure white, while the hybrid seed resulting from the second pollination were yellow. Unlike the ears where mixed pollen was used, the two kinds of seed were not indiscriminately distributed. All the white seeds were on the lower portion of the ear; all the colored were on the upper portion. This segregation of the two kinds of seed must have deprived the hybrid seed of any advantage that might be secured by crowding weak neighbors, while the time which elapsed between the two applications of pollen precluded the possibility of the hybrid seed appropriating material in advance of the pure seed.

The ear produced 212 white, or pure, seeds and 161 that were yellow, or hybrid. The average weight of the pure seed was 283 grams per 1,000. The average weight of the hybrid seed was 292.5 grams per 1,000, a difference of 9.5 $\pm$1.06 grams, or 3.4 per cent. The seeds on the lower portion of the ear are usually somewhat larger than those on the upper portion, a fact that should be considered in connection with the observed increase.

CONFLICTING RESULTS OF PREVIOUS INVESTIGATIONS.

As soon as the phenomenon of xenia came to be recognized, the possibility that size might be among the characters thus affected was perceived by a number of investigators; but, without some method of mixed pollination similar to that used in our experiments, changes in the size of seed could only be measured by comparing the average size of seed from hybrid ears with the average size of seed in the parent variety. There is such a range of individual variation in maize with regard to the size of seed that hybrid ears would have to be produced in very large numbers to recognize any but very large differences. Since hybrid ears were secured only through artificial pollination, their number was naturally small and it is not surprising that the results were more or less contradictory.

Thus Correns[1] made a series of crosses between races with different-sized seed and compared the weight of the hybrid and parent varieties. He viewed the results, however, from the standpoint of the inheritance of size as a character and paid little attention to the possibility of this being an increase due to crossing as such. With the limited number of ears which he secured it was hardly to be expected that increases of less than 25 per cent could be detected with certainty. In summarizing his results on this point, he states that while the size of the seed is not essentially changed by cross-pollination there is a slight increase in weight. By the method of mixed pollination used in our experiments differences averaging as low as 2 per cent are significant.

[1] Correns, Carl. Bastarde zwischen Maisrassen, Stuttgart, p. 30, 81, 1901. (Bibliotheca Botanica, Heft. 53.)

In cases where the ear-bearing plant produced two ears it was hoped that the effect of cross-pollination might be measured by pure seeding one of the ears and using foreign pollen on the other. In this way it might be possible to determine the effects of crossing two varieties with seed of the same color. But the normal range of variation in the size of seed between the first and second ears of the same plant when both were pure seeded was found to be so large as to obscure any differences that might be expected from the use of foreign pollen.

NATURE OF THE INCREASE.

The Chinese variety in which the phenomenon of increased size was first noticed has very small seeds, suggesting that the increase that followed crossing should be looked upon as the immediate inheritance of larger seed of the pollen parent. The other alternative is to consider the increased size of the seed as connected with the greater vigor so frequently shown in the first generation of a cross.

Roberts [1] finds difficulty upon morphological grounds in admitting the possibility of this second view. He holds that the growth stimulus of the pericarp must be inherited from one of the parents and that additional growth that resulted from a mere increase of vigor would produce an endosperm too large for the pericarp.

In the experiments here reported there is no evident relation between the size of seed in the pollen-producing variety and the amount of increase resulting from cross-pollination. In fact, the greatest increase was secured by pollinating with a small-seeded variety, and there is one instance (plant No. 219) where an increase in the size of the seed of the large-seeded Hickory King variety was secured by pollinating with a variety whose seeds weighed only half as much as those of the Hickory King. It may be necessary to conclude that the growth of the pericarp is stimulated directly by the growth of the endosperm. In experiments thus far reported, however, the necessary increase in the size of the pericarp would be comparatively slight and to seek any explanation may be superfluous. An increase of 22 per cent in the volume of a seed, which is the largest reported, would require an increase in the superficial area of the pericarp of only about 2.8 per cent.

If an increase of from 2 to 20 per cent in the weight of the seed can be secured through the stimulation of foreign pollen, the fact is of more than scientific interest. Direct evidence that important increases can be secured by allowing two varieties of the same color to cross-pollinate has been given by Carrier,[2] who secured yields of

[1] Roberts, H. F.

[2] Carrier, Lyman. Loc. cit. Preventing cross-pollination of corn by means of muslin screens. Paper read before the American Society of Agronomy, Washington, D. C., Nov. 14, 1910.

from 5 to 18 bushels more per acre when strains were allowed to cross-pollinate than when cross-pollination was prevented.

Another idea suggested by the results of these experiments is that increase in the size of the seed in the xenia generation may serve as a means of determining in advance the hybrid combinations that will produce vigorous and productive plants the following generation. Whether this proves to be the case or not, the results afford additional reason for the use of first-generation hybrid seed; but even where hybrid seed is not to be used, the planting of two varieties in alternate rows may be found to increase the yields sufficiently to warrant the additional trouble.

As the increased size is evidently a manifestation of vigor, it may be considered as a factor of adaptation, like the vigor of the first-generation hybrid plants. It would seem especially desirable to take advantage of this method of increasing the yield in regions which do not produce their own seed corn.

CONCLUSIONS.

The experiments reported in this paper afford definite evidence that the crossing of two varieties of maize is followed by an increase in the size of seed in the same year that the crossing is done. This increase is not to be confused with the increased yields secured in the year following, when the first-generation hybrid plants are grown.

By mixing pollen of a white-seeded and a colored-seeded variety and applying the mixture to the silks of the white-seeded variety pure and hybrid seed are produced on the same ear. By virtue of the xenia inheritance of seed color the two kinds of seed produced under identical conditions can be distinguished and compared.

This method makes it possible to measure the immediate increase from cross-pollination much more reliably and accurately than can be done in any experiments involving the comparison of seed produced on different plants. The results showed the hybrid seed to be heavier in every instance, the increase ranging from 3 to 21 per cent.

EXPERIMENTS ON THE DECAY OF FLORIDA ORANGES.[1]

By J. G. Grossenbacher, *Pathologist. Fruit-Disease Investigations.*

INTRODUCTION.

The oranges that dropped and decayed in many groves in Florida during the past season probably amounted to half of a medium-sized crop, but the trees had been so heavily loaded to begin with that the citrus growers generally had a very profitable year. Dropping and some decay first became very noticeable in severely ammoniated[2] groves during the latter part of October and gradually increased until the first part of December, 1912, when not only was the ground beneath the trees of ammoniated and melanosed groves covered with moldy fruit, but many trees had large numbers of decaying oranges still attached. The musty, moldy smell of such groves was noticeable at some distance. In a few small sections of the State melanose and ammoniation were practically absent. In these sections the "drops" were comparatively few, and decay, both on the trees and in transit, seemed no greater than in other years. As might have been suspected, the heavy losses from decay in shipping were chiefly confined to the sections and groves in which the dropping of fruit and decay, both on the ground and on the trees, had been great. During most of December it was not uncommon to hear reports of 20 to 60 per cent of decay in transit to market from such sections, and sometimes as high as 80 per cent decayed.

The causes of this great loss by dropping and decay are, perhaps, several and may be very complex, but it seems likely that the conditions responsible were, at least in part, the same as those causing decay in transit. While the most active agents of decay apparent in the groves during fall and early winter were the blue molds, it is not so evident how these rot organisms gained entrance to the fruits, except in so far as rinds had split or had been broken in some other way. In October and again in December, many oranges in very early stages of decay were found still attached to trees, and by careful examination with an ordinary hand lens it was sometimes possible to find one or more very minute clefts in the rind near the

[1] Issued May 3, 1913.

[2] The words "ammoniation" and "melanose" are frequently used in this paper for brevity in referring to groves having ammoniation or die-back spots and melanose roughenings on the fruit.

center of such a softening area, although in some cases no imperfections or breaks could be seen. Only rarely could a bright orange be found rotting on a tree, but usually decaying fruit was ammoniated or severely melanosed.

THE CAUSES OF DECAY.

This paper on orange decay as it occurred in Florida during the past season aims only to bring together some of the most obvious facts as related to that particular epidemic. The attention is centered chiefly on the weather conditions, diseases, and other injuries sustained by the fruit in the groves and the relation of these factors to decay. As the rot of oranges resulting from improper handling is only indirectly related to decays due to the natural environment it is unnecessary to discuss here the question of fruit handling. That phase has been fully investigated and some of it has been reported.[1]

STIGMONOSE AS RELATED TO MOLD INFECTION OF FRUITS.

In December, 1912, while looking more particularly for agents that might aid in infecting fruits which have a perfect rind, several species of pumpkin bugs or stinkbugs were found sticking their long beaks into oranges and apparently sucking the juice from the fruits. It is, of course, uncertain just how effective such punctures are in carrying the mold spores which may be present on the rind into the fruit, but since the bugs were fairly common and could often be seen making three or four punctures in a few minutes it is probable that only comparatively few of their punctures caused infection, in spite of the fact that the mold spores were plentiful throughout the groves. On making hand sections of such orange rinds, especially where very tiny discolored spots could be found in the rag or where one or more pulp cells were found partially empty or discolored, it was sometimes possible to get fairly good views of the path of the puncture through the rind by the rod of yellow gumlike substance which occupied its place. No indication of the puncture was visible on the surface view, even after such a canal or rod had been exposed in section. The surface cells seem to close in on the withdrawal of the beak. In a number of such sections of orange rinds the tissue of the inner portion of the outer rind surrounding a bug puncture was found dead and discolored, but it was impossible to demonstrate the presence of a fungous mycelium in these inconspicuous early stages. Nevertheless, it is likely that this stigmonose of the orange was responsible for many mold infections and considerable decay during the height of the period

[1] Tenny, L. S., Hosford, G. W., and White, H. M. The decay of Florida oranges while in transit and on the market. U. S. Department Agriculture, Bureau of Plant Industry, Circular 19, p. 8, 2 fig., 1908. See also Ramsey, H. J., Proceedings, Florida State Horticultural Society, 1912.

of rot in December. Infection with mold by means of stinkbug punctures would, of course, not be evident until the oranges had become soft. The manner of infection would also be mysterious, because no evident injury could be found on the rind. Figure 1 is a camera drawing giving a good general idea of these punctures and the early stages of disorganization surrounding them. Possibly some of the disintegration is due simply to a poison secreted by the mouth parts of the insects. It so happened that in February, when decay in the groves was very slight as compared to that occurring in December, no stinkbugs could be found in the groves.

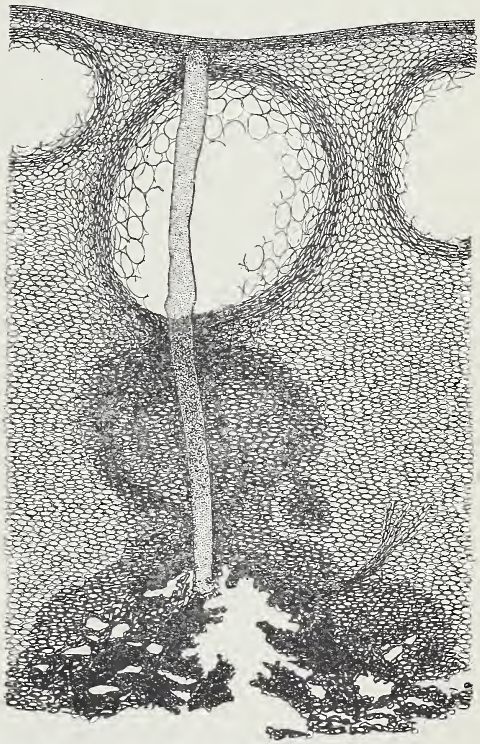

Fig. 1.—Section of orange rind, showing gummous tube or rod where beak of insect had punctured and disintegration of tissues from within outward. Magnified to about 26 diameters. Drawn by J. Marion Shull.

WET WEATHER AND SPLITTING INDUCING DECAY.

The very wet weather prevailing during practically the entire summer was doubtless indirectly responsible for most of the rot, not only because it favored the occurrence of both ammoniation and melanose in great abundance, but thereby also resulted in many clefts in the rind, some large and some small. These rind injuries, in connection with the abundance of blue-mold spores, were, perhaps, the greatest immediate cause of decay in the groves, as well as of the earlier part of the heavy decay in transit.

The creasing and splitting of oranges occur commonly in the fall and winter following a wet season or after a wet period preceded by a drought. A drought checks the growth of the fruit and hardens the rind and, if followed by good growing weather, ruptures may occur. However, when wet weather lasts all summer, ammoniation and melanose are likely to be abundant and consequently result in many splits.

The forces which actually cause the creasing and splitting have not been determined, but have been deduced from the conditions of weather and growth prevailing during the seasons when ruptures of the rind are prevalent; that is, the facts observed have been pieced together and the gaps existing in our knowledge filled in by assumptions in such a way as to make a more or less complete story. This theoretical explanation is only provisional and awaits the results of experimental examination before it can be considered a real explanation.

Many orange rinds sustain ruptures during or after a prolonged wet period following a drought which prevailed while the fruit was making the latter part of its growth. The growing weather following such a drought causes the pulp to renew its growth and distend the rind. Since the tissue of the inner rind, or rag, loses its vitality before that of the outer or oil-bearing portion, its stretching capacity is more limited and, therefore, more often ruptures, while the outer rind becomes simply more distended. However, when wet weather prevails throughout the summer, as in 1912, the growth of the pulp may be practically continuous, but, owing to the fact that such a wet season is accompanied by the development of ammoniation and melanose, the outer rind loses its capacity for continued growth and distention and therefore splits. When the outer rind is bright or uninjured, it may be stretched to meet considerable increase in the size of the pulp mass; and if ruptures occur under such conditions usually only the inner rind, or rag, is ruptured, resulting in what is known as creased fruit. In either case the rind of such fruits is found to be very tight or under a very high internal pressure at the time the ruptures occur.

If oranges which have an internal growth-and-sap pressure almost great enough to burst the rind were placed in a strong air-tight vessel into which more air is pumped until the air pressure inside the vessel is much higher than that outside, the rind on the inclosed oranges would become fairly loose, simply because the air pressure on the outside of the oranges (in the vessel) is now much greater than the growth-and-sap pressure inside the oranges. On the other hand, if, instead of pumping more air into the vessel containing the oranges, air is pumped or drawn out so that the air pressure inside the vessel is much less than the pressure outside, the expansive forces inside the oranges (growth-and-sap pressure) will be so much less restrained by the diminished air pressure surrounding the inclosed fruits that their rinds will burst. In other words, if the pressure in the oranges has reached a height which is almost sufficient to result in creasing or splitting and then a period of low barometer or low atmospheric pressure comes on, there are almost certain to be many split or creased fruits, while a rise of the barometer or an increase in the atmospheric pressure would probably have prevented the ruptures. The position and tension of the orange rind is a resultant of the interaction between the internal pressure existing in the fruit and the resistance of the rind and atmospheric pressure outside.

MELANOSE AND AMMONIATION AS RELATED TO THE OCCURRENCE OF DECAY.

As intimated, a rather striking constancy was noticeable in the prevalence of melanose and ammoniation in groves where many fruits were decaying both on the ground and on the trees. It was also noticed that the unusually high percentage of decay of oranges in transit during late November and the month of December was confined almost wholly to those sections of Florida in which the fruits were affected with melanose and ammoniation. In other words, the only sections of the State in which rot was not heavy were the few in which the oranges were neither melanosed nor ammoniated.

Whether it is possible to introduce some factors which would prevent such a wholesale dropping and decay in the groves can not be definitely stated at present, but the question is important enough to merit some very careful study. In a detailed study of the factors in picking and packing fruit which contribute to decay in transit, valuable and suggestive results have been obtained by the Office of Field Investigations in Pomology of the Bureau of Plant Industry. It was demonstrated beyond a doubt that by the older and more careless methods of picking and handling the fruit a considerable amount of decay was induced by injuring the rinds in various ways. But the difference between the decay ordinarily due to such careless handling and that which occurred last year in the oranges from most of the State is very evident and is quite large. A number of carefully run packing houses located in regions where melanose and ammoniation were prevalent sustained heavy losses from rot in transit in spite of the additional care taken to avoid the trouble. On the other hand, some packing houses doing business in sections free from melanose and ammoniation experienced but little more than the ordinary amount of rot in transit. In view of such results obtained in the uncommon years, it seems advisable to continue the study of the decay of oranges in transit and to pay special attention to factors in the groves that may be related to the occurrence of such extraordinary seasons as the one just past.

The unusually high percentage of decay in severely melanosed and ammoniated groves, as well as the enormous loss in transit from such groves when compared with results obtained in groves free from both of these diseases, indicates either that melanose and ammoniation on oranges predispose them to rot or else that the conditions favoring the development of melanose and ammoniation are themselves the predisposing factors. In quite a number of groves where the splitting, dropping, and decay amounted to perhaps a fifth of the crop, ammoniation was the only kind of rind injury to be found. Once all the details of the cause of ammoniation are known, it may be possible to prevent much of this loss.

THE RELATION OF MELANOSE TO STEM-END ROT.

In view of the paper recently published by Floyd and Stevens,[1] in which some suggestive evidence is given to show that melanose is due to the same fungus that causes stem-end rot, it seems highly probable that by preventing melanose at least a portion of the decay can be prevented.

EXPERIMENTS ON THE PREVENTION OF MELANOSE.

Some experiments are now under way on the prevention of melanose under grove conditions. Lime-sulphur as well as Bordeaux mixture is being used as nearly as possible according to the suggestions given in the above-mentioned paper by Floyd and Stevens. In case the disease is prevalent again this year it will be possible to get some idea of the feasibility of using a fungicide for its control.

DOES STELLATE MELANOSE ON LEAVES HARBOR PHOMOPSIS CITRI?

Even in a season like the last, when the leaves, young growth, and fruit of thousands of both pomelo and orange trees are literally covered with melanose roughenings, very few fruiting bodies of the causal fungus were found on the dead twigs of such severely affected trees. That makes one wonder what could have been the source of all the infectious material required to produce such untold millions of infections. It appears that ordinarily *Phomopsis citri* is not to be found in the melanose roughenings on the leaves, shoots, or fruits. The injury resulting in the rough spots is thought to be due to some enzymotic substance liberated by the spores of the fungus on germination. The melanose spots are usually pinheadlike cushions of cork raised above the general surface of the citrus tissues, but in some cases a later enlargement of these circular spots occurs, in that three or more short ridges develop as radii about the original circular spot. This stellate form of melanose was found very abundantly during February and March, 1913, in one of the smaller orange groves of the Manatee Fruit Co. near Palmetto. Now, since the fruiting bodies of the Phomopsis are so few on the dead twigs of severely affected trees,

[1] Floyd, B. F., and Stevens, H. E. Melanose and stem-end rot, Florida Agricultural Experiment Station, Bulletin 111, 16 p., 9 figs., 1912.

it was thought possible that under certain unknown conditions the fungus may actually be present in the original melanose spots and by further growth induce a development of stellate spots and finally produce spores and thus infect the new growth of leaves, fruits, and shoots. These stellate melanose spots have been studied carefully in thin sections, but fungus mycelium could not always be found in them, although some was often present. The accompanying illus-

FIG. 2.—Stellate melanose spots on upper side of orange leaf, showing the older circular spots in the center. Magnified about 7½ diameters. Photographed by Dr. Albert Mann.

trations (figs. 2 and 3) give a fair idea of the stellate spots as they appear under an ordinary magnifying glass.

EXPERIMENTS TO DETERMINE THE CAUSE OF DECAY.

Since the general opinion prevailed, both among the growers and shippers, that the rot was chiefly due to Penicillium or mold and because the heavy decay was confined to groves that had melanosed and ammoniated fruit, it seemed worth while to determine what relation could be shown to exist between those rind diseases and decay.

A TEST AT ORLANDO.

In order to make a preliminary test, bright, ammoniated, and melanosed oranges were carefully picked in early February near Orlando, Fla., and sprayed with blue-mold spores obtained from freshly decayed oranges secured from a packing house near the

Orlando Field Laboratory. After drying, five bright, five melanosed, and five ammoniated fruits were wrapped and put into separate covered glass vessels. The vessels were stored on shelves in the laboratory. Twelve days later the following results were found: In the dish containing the melanosed oranges one was about half decayed and two others were slightly softened at the stem end, but no blue mold was evident. In the dish containing the ammoniated fruits two were entirely decayed and the blue mold had covered the outer surface of the paper wrappers with its spore masses; another orange

FIG. 3.—Stellate melanose as occasionally seen on the under side of leaves. Magnified about 7½ diameters. Photographed by Dr. Albert Mann.

was about one-fifth decayed at the stem end, but had no blue mold in evidence. The bright fruits were apparently as good as when picked two weeks before. Although these numbers are small, the results are suggestive, because they are so pronounced on fruits which had been carefully picked and handled. The difference between the 60 per cent of decay of the rough-rinded oranges and the entire absence of decay in the bright fruit was so great that it was decided to make further tests. It appeared rather extraordinary that half of the oranges were decaying by an organism distinct from the one used in the water sprayed on the fruit.

THE FIRST TEST IN WASHINGTON.

It also seemed possible that oranges from a vigorous tree might prove more resistant to decay than those from a tree that had been much weakened by crown-rot (foot-rot), even when the rind of both is in about the same condition. In order to open the way for some future work along that line, melanosed fruits were selected from both normal and foot-rotted trees and carefully marked when packing. Ammoniated fruits were taken from vigorous-looking trees.

The fruit was carefully packed and expressed to Washington, D. C., from Orlando, Fla., on February 28. Owing to unforeseen conditions, it had to be held in Washington at room temperature until March 10 before being unpacked to start the experiment. At that time several ammoniated oranges were found decayed, apparently by blue mold, and several melanosed fruits and one bright orange were in the early stages of stem-end rot, as indicated by obtaining *Phomopsis citri* from their interior. A number of melanosed and ammoniated fruits were rather soft and flabby. Only the firm ones were used in the experiment, the details of which are given in Table I. A portion of each type of fruit was sprayed with water by means of an atomizer, and the other fruit was sprayed with a suspension of the Penicillium or mold spores obtained from vigorous pure cultures formerly secured from moldy oranges. The mold used seems to be most like *Penicillium italicum,* but at present its identification is uncertain.

After drying, the fruits were wrapped with ordinary orange wrappers and each kind placed in separate covered glass dishes. The fruit was all held at room temperature for three days and then some was transferred to a refrigerator having a temperature of about 15° C. (60° F.). On March 17, or a week after the beginning of the experiment, the oranges were all carefully examined for decay, and cultures were made from the interior of many of the fruits which seemed to be affected by stem-end rot, although the decay was not of sufficient extent to be certain. All but two of such doubtful ones were found to contain *Phomopsis citri.* The fungus obtained from the two other oranges proved to be neither Phomopsis nor Penicillium, and not having produced its spores as yet in culture it still remains unknown. The relation of *Phomopsis citri* to stem-end rot was established by Fawcett,[1] who also showed that the decay is not preventable by the application of a fungicide.

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[1] Fawcett, H. S. Stem-end rot of citrus fruits. Florida Agricultural Experiment Station, Bulletin 107, 23, p. 9 figs., 1911.

TABLE I.—*Experimental test of the causes of decay of oranges.*[1]

Experiment and character of the fruit used.	Fruits kept at room temperature throughout the experiment.								Fruits placed in a refrigerator at 15° C. (60° F.) 3 days after the treatment.								Grand total.		
	Sprayed with water.				Sprayed with spores.				Sprayed with water.				Sprayed with spores.						
	Number used.	Decayed.			Number used.	Decayed.			Number used.	Decayed.			Number used.	Decayed.			Number used.	Number decayed.	Decayed.
		St. E.	Bl. M.	Per cent.		St. E.	Bl. M.	Per cent.		St. E.	Bl. M.	Per cent.		St. E.	Bl. M.	Per cent.			
Experiment 1.—From Mar. 10 to Mar. 17, 1913:																			*P. ct.*
Brights	5	0	1	20	10	1	0	10	......	......	......	......	......	......	......	......	15	2	13½
Melanosed—																			
From foot-rotted trees	4	0	1	25	4	3	0	75	......	......	......	......	4	1	0	25	12	5	41⅔
From normal trees	5	4	0	80	15	8	2	66⅔	5	2	0	40	5	1	0	20	30	14	46⅔
Ammoniated	5	1	2	60	10	3	2	50	5	1	0	20	10	3	0	30	30	12	40
Total	19	5	4	47⅓	39	15	4	48⅔	10	3	0	30	19	5	0	26⅓	87	33	37 9/10
Decayed ... per cent	......	26⅓	21 1/19	......	......	38½	10¼	......	......	30	0	......	......	26⅓	0	......	......	......	......
	Fruits kept at room temperature throughout the experiment.								Fruits kept at refrigerator temperature of about 15° C. (60° F.) throughout the experiment.								Grand total.		
	Untreated.				Sprayed with spores.				Untreated.				Sprayed with spores.						
	Number used.	Decayed.			Number used.	Decayed.			Number used.	Decayed.			Number used.	Decayed.			Number used.	Number decayed.	Decayed.
		St. E.	Bl. M.	Per cent.		St. E.	Bl. M.	Per cent.		St. E.	Bl. M.	Per cent.		St. E.	Bl. M.	Per cent.			
Experiment 2.—From Mar. 24 to Apr. 7, 1913:																			*P. ct.*
Brights	5	2	0	40	10	3	0	30	3	0	0	0	......	......	......	......	18	5	27 7/9
Melanosed	5	4	0	80	10	6	0	60	5	0	0	0	......	......	......	......	20	10	50
Ammoniated	5	1	0	20	10	4	1	50	4	0	0	0	5	1	0	20	24	7	29 1/6
Total	15	7	0	46⅔	30	13	1	46⅔	12	0	0	0	5	1	0	20	62	22	35 2/5
Decayed ... per cent	......	46⅔	0	......	......	43⅔	3⅔	......	......	0	0	......	......	20	0	......	......	......	......

[1] St. E.=decayed at the stem end and not overgrown by mold. Bl. M.=decayed and overgrown by blue mold.

Several interesting facts are evident from the data recorded in experiment 1 of Table I. Perhaps the most striking thing here is that fruits treated with mold spores were but little more subject to decay than those not so treated. Another important point that may have a wide practical bearing if further experiments confirm it is the fact that even though three days were allowed for the incubation of the oranges treated with blue mold before they were removed to a temperature of 15° C. (60° F.), no case of blue-mold decay resulted in the refrigerator in a total of 19 sprayed with spores. Of the total number of fruits decayed, only $28\frac{4}{7}$ per cent were rotted by blue molds, while $71\frac{3}{7}$ per cent decayed by stem-end rot. Two of these fruits rotting at the stem end were afterwards shown to contain a very rank-growing fungus which has not yet sporulated in culture, while the others contained *Phomopsis citri*. It is also worth noting that of the oranges sprayed with Penicillium spores and held at room temperature throughout the experiment, $38\frac{1}{2}$ per cent decayed at the stem end and only $10\frac{1}{4}$ per cent had blue mold. Of the total of 58 oranges treated with mold spores, 24 decayed; of these, 20, or $83\frac{1}{3}$ per cent, were decayed by Phomopsis, while only $16\frac{2}{3}$ per cent of them were rotted by blue mold.

THE SECOND TEST IN WASHINGTON.

In order to get an idea of any change that might occur in the percentage of decay as the season advances and to study further the effect of refrigeration as a preventive of rot, another test was begun on March 28. Mr. Leslie Pierce, who was supervising some spraying work on the prevention of melanose in Florida, picked and sent to Washington, D. C., from Orlando, Fla., melanosed, ammoniated, and bright oranges to be used in the experiment.

In this case some of the fruits were sprayed with the spores of the common citrus blue mold, *Penicillium italicum*, and others with a dark olivaceous species also found on oranges and which appears to be *Penicillium olivaceum*. But owing to the fact that the application of mold spores seems to have had so little effect the two fungi are not distinguished in the records as given in experiment 2 of Table I.

The data in this second experiment are again rather surprising, both in regard to the relative numbers of oranges decayed by *Phomopsis citri* and by mold and in regard to the effects of only moderately low temperature in checking or preventing the decay. Of 30 fruits sprayed with spores and held at room temperature, 14 decayed; 13 of them, or $92\frac{6}{7}$ per cent, were decayed by *Phomopsis citri*, and only $7\frac{1}{7}$ per cent by Penicillium. Only 5 of the total 17 held in a refrigerator had been treated with mold spores; 1 of the 5, or 20 per cent, had a very slight indication of decay at the stem end. This would tend to strengthen the evidence afforded by the former experiment in making it appear worth while to precool oranges for transportation when they are taken from groves which yield a high percentage of decay.

SUMMARY AND CONCLUSIONS.

These preliminary experiments are too small and few to permit any but tentative conclusions, yet the results are so clear cut and uniform in regard to some of the significant points that they may be specially noted. In the first place, it should be borne in mind that the condition of the fruit at maturity is a resultant of the environment of the grove during the growing season. Coincident with the uncommonly wet season of 1912 melanose and ammoniation of the fruit were prevalent over most of the citrus region of Florida, and it is very probable that the wet weather was directly related to the occurrence of such rind injuries. The excessive moisture of both the soil and the air in connection with these injuries resulted in numerous splits and rind distentions, which caused an enormous development of mold in the groves. The presence of large numbers of stinkbugs, which suck juice from oranges, probably also added to the epidemic by inoculating sound fruits when inserting their beaks through portions of rinds on which the air currents had deposited mold spores. The rather muggy warm weather prevailing in late November and in December doubtless also contributed to the heavy decay of that time, for these experiments indicate that temperatures no lower than 15° C. (60° F.) practically prevent the development of the mold rot.

But in addition to the mold-rot epidemic induced by the split and cracked rinds, much fruit dropped and decayed which was not split. The above results make it appear probable that *Phomopsis citri* was responsible for most of the rot of that type except what was due to bug-puncture infections. This also agrees with the fact that melanose was very abundant in the districts where much fruit decayed. However, the scarcity of phomopsis pustules on the dead twigs during late fall and winter argues that this fungus may sporulate elsewhere or that its mycelium persists in some melanose spots on the stem or calyx of the fruit.

Perhaps the most important conclusion that these observations force upon us is the importance of growing fruit that is free from melanose and thus not only obviating a reduction in the market value of the fruit but also preventing some splits and most of the stem-end rot. The fact that the refrigerator temperature used in these experiments practically prevented all decay suggests that shipping tests should be made with precooled fruit in refrigerator cars and boats.

THE WILD PROTOTYPE OF THE COWPEA.[1]

By Charles V. Piper, *Agrostologist, in Charge of Forage-Crop Investigations.*

In a recent bulletin the writer has given an extended account of the cultivated forms of Vigna known as cowpeas, catjangs, and asparagus beans, all the data and conclusions being based on cultivated material.[2] In that bulletin the three were considered different species, namely, *Vigna sinensis, V. catjang,* and *V. sesquipedalis,* but it is pointed out that all can be crossed readily and that a perfect series of intergrades exists in respect to all characters.

In a previous bulletin Mr. W. F. Wight[3] has gone into great detail into the early history of this same group, reaching the conclusion that they represent three distinct species and—

That both *Vigna sinensis* and *V. catjang* originally came from the region including and extending from India to Persia and the southern part of the Trans-Caspian district, and that the Persians called one or both of them by the name "lubia" and applied that name to *V. sinensis* in northwest India after their conquest of that region. The cultivation of *V. sinensis* extended to China at a very early date, but the distribution of at least one of the species with the name "lubia" has extended from the region of its origin at the beginning of the Christian Era to Arabia and Asia Minor and had reached some of the Mediterranean countries of Europe at about the same time, but did not become known in Central Europe until the middle of the sixteenth century.

One difficulty in accepting Wight's conclusion as to the original habitat of the cowpea is the fact that no wild plant is known in the region indicated that could in any likelihood be the wild prototype. This difficulty is, however, paralleled by a similar one in the case of maize, kidney bean, and other plants cultivated from remote antiquity. Still earlier the subject had been discussed by Körnicke,[4] who reached the conclusion that all the cultivated forms known as cowpeas, catjangs, and asparagus beans represent but one botanical species, *Vigna sinensis,* whose native habitat he believed to be central Africa. He based this opinion on specimens collected by Schweinfurth, by Schimper, and by Kotschy, but enters into no botanical discussion regarding the identity of the wild with the

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[1] Issued May 3, 1913.

[2] Piper, C. V. Agricultural varieties of the cowpea and immediately related species. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 229, 160 p., 12 pl., 1912.

[3] Wight, W. F. The history of the cowpea and its introduction into America. U. S. Department of Agriculture, Bureau of Plant Industry, Bulletin 102, pt. 6, p. 59, 1907.

[4] Körnicke [Ueber von Apotheker Winter bei Gerolstein aufgefundene neue und seltenere Pflanzen.] Verhandlungen, Naturhistorischer Verein der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück, Jahrg. 42 (F. 5, Jahrg. 2), Correspondenzblatt 2, p. 136–153, 1885.

cultivated plant. Indeed, it is not clear that he examined the actual specimens, as he writes, "I predict that the wild forms are slender and twining and bear pods which, when ripe, spring open." (Translation.)

A recent opportunity to study the Vigna material in the Berlin, Kew, and British Museum herbaria and the study of the wild African plant under cultivation has led to the conviction that Körnicke's conclusion regarding the native plant of Africa being the wild form of the cultivated cowpea is correct. The wild species itself is quite variable, and its relationship to other supposedly distinct species is not clear. Until these supposed distinct species are also studied under cultivation there must remain some doubt as to their actual affinity. From herbarium studies the following facts are adduced and conclusions offered:

Southward from the Sahara Desert and extending across the continent is a wild plant that differs from most cultivated catjangs only in the following characters, viz: The leaflets are minutely scabrous on the upper surface and the petiolules are usually pubescent; the small pods are dark colored, scabrous, 7 to 8 centimeters long, and in dehiscence the valves coil tightly. In herbaria this plant is usually labeled either *Vigna sinensis* or *Vigna nilotica*, and on one of Schweinfurth's sheets the name *Vigna spontanea* is written.

The numerous collections of this plant include specimens from Egypt, Nubia, Kordofan, Abyssinia, German East Africa, Zanzibar, Senegal, Gold Coast, Kamerun, Nigeria, Angola, Rhodesia, Natal, and Madagascar. It is sometimes cultivated, as indicated by Schweinfurth's No. 1778 collected between Debenhuch and Keneh, Egypt, and No. 888 from Khartum. Lederman also found it cultivated at Garua, Kamerun, as shown by his specimen No. 5149a. Stuhlman's collections in Zanzibar give the native name as "kunde" or "kunde ya muita," and state that the wild bean is not eaten. The name "kunde" is, however, generally applied to the cultivated cowpea in German East Africa, or, according to Braun,[1] the seeds are called "kunde" and the plants "mkunde."

In northern Nigeria the wild plant is called "gayan-gayan" and seeds from specimens collected in Sokoto, Northern Nigeria, by Dr. J. M. Dalziel (No. 318, October, 1910), germinated freely and grew in a greenhouse in Washington. The nearly black scabrous pods are about 10 centimeters long. The seeds are 5 millimeters long, buff, marbled with brown, speckled with minute blue dots, and have a few black blotches. Mr. George W. Oliver has already crossed this plant with various varieties of cowpeas. Prof. W. J. Spillman hazards the prediction that the wild plant contains in its seed colors all the

[1] Braun, K. Bestimmungstabellen für die Eingeborenenkulturen von Deutsch-Ost-Afrika. Der Pflanzer, Jahrg. 7, No. 8, p. 440, 1911.

color factors found in the numerous cultivated varieties, except perhaps the "eye." The hybrids above mentioned have been made partly with the idea of clearing up this point.

The numerous cultivated forms of Vigna in Africa are mostly true cowpeas, and about 40 varieties from Egypt, Sudan, Rhodesia, Transvaal, British East Africa, and German East Africa have been grown in comparative trials and are described in Bulletin 229 already cited. In Angola occur cowpeas distinguished by having more or less retrorse pubescence, especially on the stem. These have not been grown in our trials, but excellent botanical material was collected by Welwitsch, who considered the plant a distinct species, *Vigna macundi*. Except for the small amount of pubescence, however, there is nothing to distinguish it from an ordinary cowpea, Welwitsch[1] speaks of it as commonly cultivated and occasionally spontaneous. About Golungo Alto, Angola, the native name is "macundi" (plural) and "licundi" (singular) both suggestive of "kunde," the native name of the cowpea in German East Africa.

The asparagus bean apparently is rare in Africa, only one lot, S. P. I. No. 11091, from Abyssinia, having been secured.

The catjang is not infrequent in Africa. In Bulletin 229 four varieties from Abyssinia are described, and Schimper found it abundantly cultivated near Humboldt Springs, Djur Land, Anglo-Egyptian Sudan. From the wild cowpea the catjang differs mainly in having the pods pale and smooth instead of dark and scabrous, but all intergrades occur. A form with pale, scabrous pods was collected by Ehrenberg in cultivation at Gumfuda [Kunfuda], Arabia. In all probability this is the same as the Egyptian plant named *Dolichos lubia* by Forskal, also described as having scabrous pods. Similar specimens have been collected in the Seychelles (I. Horn, No. 474, in 1874) and in Java (Surokarta, Horsfield). Such specimens also come from Meshra el Zaraf, Sudan, with the information: "Eaten by cattle; seeds eaten by natives during the year of drought; native name, 'Lubiet el Gazal.'"

Besides the above-mentioned plants, all of which are undoubtedly referable to *Vigna sinensis*, there occur in the southern half of Africa other forms where relationship to the cowpea is less clear.

The commonest of these is the plant known botanically as *Vigna triloba* Walpers, which differs from the wild cowpea mainly in its leaflets being almost always three lobed. Some of the labels indicate also that the plant is not a true annual, but from herbarium specimens this can not be determined. Unless there is a distinction in the matter of life period or duration, *Vigna triloba* can not be kept distinct from the wild form of *Vigna sinensis* by any character yet

[1] Hiern, W. P. Catalogue of the African plants collected by Dr. Friedrich Welwitsch in 1853–61, pt. 1, London, 1896, p. 260.

pointed out. The lobing of the leaves is very variable and commonly occurs in cultivated *Vigna sinensis*, especially when in poor soil.

Vigna triloba occurs mainly south of the Equator, where it is apparently never cultivated. However, specimens collected by Dr. J. M. Dalziel in the Katagum District, Northern Nigeria, May, 1908, which seem indistinguishable from *Vigna triloba*, bear the legend "Common cultivated bean of the fields."

In Angola, forms of *Vigna triloba* with narrow leaflets occur. Such specimens are represented by Welwitsch's No. 2262 from Loanda and No. 2263 from Pungo Andongo. On the former of these Welwitsch has recorded "a herb persisting for several years but scarcely perennial," and on the latter "a herb enduring apparently for several years." Gossweiler has more recently made collections in the same region. His No. 4802 from Grongude, apparently identical with Welwitsch's No. 2262, is stated to be "a perennial many-leaved vine, with large blue flowers," while his No. 1534 from Penedo, quite the same as Welwitsch's No. 2263, bears the legend "a perennial climber."

Differing from this narrow-leaved plant mainly in being pubescent is a form occurring in Natal, Transvaal, etc., which was called *Scytalis protracta* by E. H. F. Meyer. All recent botanists have considered this only a form of *Vigna triloba*.

Another form with still narrower leaflets and lacking the pubescence has been named *Vigna triloba stenophylla* Harvey and Sonder.[1]

In the light of present evidence it is not clear that *Vigna triloba* is specifically distinct from the wild *Vigna sinensis* of Africa. On the other hand, the statements of Welwitsch and of Gossweiler that *Vigna triloba* persists more than one year indicate that it is different, in this respect at least, from *Vigna sinensis*. The trilobed leaflets as a mark of distinction can not be depended upon, yet in classifying specimens this is the only evident character. In the herbarium at Kew are specimens of both species, so far as this distinction may be depended upon, collected by Dr. J. M. Dalziel in the Katagum District, Northern Nigeria. The one referable to *Vigna triloba* is said to be "the common cultivated bean of the fields," while no data regarding the habitat of the other are recorded.

There is scarcely room for doubt, however, from the ample herbarium material, that the African plant with blackish scabrous pods and scabrous leaflets found wild over a great area and occasionally cultivated is the original wild form of our cultivated cowpea. This conclusion is further confirmed by a study of comparative cultures and the fact that hybrids between the wild plant and the cowpea are readily obtained. Whether *Vigna triloba* is to be considered a distinct species can hardly be decided in the light of present evidence.

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[1] Harvey, W. H., and Sonder, O. W. Flora Capensis, v. 2, Dublin, 1861-2, p. 241.